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IMPLANTATION AND INJECTION OF SYSTEMIC CHEMICAL INSECTICIDES IN DOUGLAS-FIR IN IDAHO TO INCREASE SEED YIELD

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by

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INTRODUCTION

In Idaho, Rocky Mountain Douglas-fir, Pesudotsuga menziesii var. glauca (Beissn.) Franco, cone production is highly variable with one good crop occurring about every five years. A complex of insect pests (Kulhavy et al. 1975) causes losses in cone production and quantities of viable seed (Clark et al. 1963). The western spruce budworm, Choristoneura occidentalis Freeman (WSBW), is the most serious pest, as early-stage larvae can destroy conelets before and just after pollination and late-stage larvae feed on the more developed cones. One WSBW larva often feeds on more than one cone during development and most seed in infested cones is either destroyed directly or retained within cones by growth distortions and excess resin.

Implantation and injection of systemic chemical insecticides offer promise for individual tree protection. Both systems provide a portable method of delivery that minimizes insecticide loss making them environmentally safe and practical for use in remote or hard-to-reach locations.

Medicaps^{R} (Creative Sales, Inc., Fremont, NE 68025) containing powdered acephate[3] (ACECAPS^{R}) are used in protecting foliage and reducing WSBW larval populations on grand fir, Abies grandis (Dougl. ex. D. Don) Lindl., and Douglas-fir (Markin 1979, Reardon and Haskett 1981, Reardon 1984). ACECAPS^{R} implanted at 10 cm spacing are registered for control of budworms in the United States.

Mauget systemic injector units (J.J. Mauget Co., Burbank, CA 91504) containing liquid oxydemeton-methyl (Inject-A-Cide^{R}) are effective in reducing number of Douglas-fir cone moth, Barbara colfaxiana (Kearfott), and increasing seed yield on Douglas-fir in California (Koerber 1978, Dale and Frank 1981). Inject-A-Cide^{R} units injected at 15 cm spacing are registered for control of the Douglas-fir cone moth in the United States.

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3 This paper reports the results of research only; mention of a proprietary product or pesticide does not constitute endorsement or recommendation for use by the U. S. Department of Agriculture

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EXPERIMENT STATION

Bendiocarb, another insecticide available as an implant, is a residual carbamate insecticide. It has been used to suppress household pests but has not been tested for cone protection.

This paper reports a study to determine the effectiveness of acephate and bendiocarb implanted at 10 cm spacing, and oxydemeton-methyl injected at 10 and 15 cm spacings in Douglas-fir to improve seed yield.

MATERIALS AND METHODS

Area and Tree Selection

We located two study areas in March 1982 based on elevation; cone crop potential as determined by collecting 45 cm midcrown branch samples and assessing reproductive bud development; and predicted WSBW populations as determined by aerial survey of defoliation in 1981.

One study area was located on the Payette National Forest near Price Valley, Idaho. This area had light Douglas-fir defoliation in 1981 and anticipated low density populations of WSBW. The Douglas-fir at 2,000 m elevation ranged in height from 15 to 30 m and averaged 48 5.2 cm in diameter at implant height (i.e., used instead of breast height due to 1 to 3 m of snow on ground).

The second study area was located on the Boise National Forest near Idaho City, Idaho. Douglas-fir in this area was heavily defoliated in 1981 and anticipated high density populations of WSBW. The Douglas-fir at 2,000 m elevation ranged in height from 10 to 20 m and averaged 40 7.5 cm in diameter at implant height.

Fifty Douglas-fir (10 trees per treatment for 5 treatments) were selected in each area. Most of the sample trees were separated by a distance of at least one chain, numbered and randomly assigned one of 5 treatments: Mauget injection units containing oxydemeton-methyl at 15-cm and at 10-cm spacings, Medicaps containing bendiocarb or acephate at 10 cm spacing, and untreated checks.

Treatment

The powdered formulations of acephate, as 97% Orthene , and bendiocarb, as 97% bendiocarb, were introduced directly into the xylem tissue in Medicap plastic cartridges (1 cm x 3 cm), inserted into holes drilled with a 1-cm bit to a depth of about 3.2 cm beyond the inner bark. Each cartridge was tapped with a bolt and hammer, so that the outer end of the cartridge was slightly below the cambium surface. The gelatin capsule encased within the hard plastic, perforated shell was dissolved and the insecticide distributed by the sap. The number of cartridges required per tree was determined by dividing the trunk circumference by 4. The holes were spaced at approximately 10 cm intervals. Each Medicap cartridge contained 0.9 gm active ingredient (AI) of acephate or 0.5 gm AI of bendiocarb.

The liquid formulation of oxydemeton-methyl, as 50% Metasystox-R^{R}, was injected into the xylem tissue using Mauget systemic injection units. Each unit consisted of a plastic portion (3 by 4.5 cm) containing the insecticide with an attached 10-cm feeder tube that was inserted into holes drilled into the xylem tissue. The holes for the feeder tubes were drilled at a slight downward angle with 0.44-cm bit at approximate 10 cm or 15 cm spacing intervals. Each Inject-A-Cide^{R} unit contained sufficient insecticide to maintain the registered dose of 0.1 gm AI per cm of circumference for both spacing intervals. The 10 cm spacing interval was selected in addition to the registered (15 cm) spacing in an attempt to improve insecticide distribution within the crown; thereby, increase insect mortality.

Sample trees were treated on 19 May in Price Valley and on 20 May, 1982 in Idaho City; cone buds were expanded and vegetative buds were still tight.

Cone Collection

Cones were collected periodically from sample trees using an extendable pole pruner with attached cloth basket. One to three 45-cm branch samples removed from the upper one-half of the crown were used to collect 10 cones per tree per sample time. Samples were taken at approximately 22 (10 June) and 54 (12 July) days after implantation or injection. The cones were examined using a magnifier and the percent of undamaged cones per tree recorded.

Fifty mature cones were collected from each sample tree. Twenty-five cones from each tree were placed in a paper bag, allowed to air dry, shaken, and total seeds dislodged from the cones recorded. One hundred seeds from each tree were x-rayed to determine the percent filled, hollow or damaged by insects. An additional 25 cones from each tree were sliced longitudinally in half along the cone axis using cone cutters for axial slice surface analysis. One surface of each cone was examined for the number of filled, hollow or insect damaged seed. Only sliced seeds were examined.

Three one bushel samples of mature cones were collected among sample trees for each treatment, using pole pruners and by climbing the trees. These cones were processed at Lucky Peak Nursery located near Boise, Idaho. At Lucky Peak, the cones were air and kiln dried, followed by tumble extraction of the seed, seed dewinging and air separation of filled and empty seeds. A subsample of 300 seeds was taken from seeds visually determined as "filled" that were recovered from each bushel and x-rayed to determine the percent filled, hollow and damaged by insects. A subsample of 200 sound seeds from each treatment was forwarded to the Idaho State Seed Laboratory to determine percent germination.

WSBW and Coneworm[1] Sample

Larval densities of WSBW and coneworms were estimated on treated and check trees approximately 54 days after treatment (12 July) to provide an estimate of larval density prior to pupation. The sampling procedure consisted of counting larvae and new vegetative shoots on the branch samples removed to collect developing cones (Carolin and Coulter 1972). In the

[1] Dioryctria abietivorella (Grote)

laboratory, the branches were beaten inside a barrel to dislodge the larvae (Martineau and Benoit 1973). For each sample tree, WSBW and coneworm densities were recorded as the number of larvae per 100 shoots.

Analysis

The average number of filled seed per cone for the various treatments was analyzed for each area separately by using Games and Howell T modification for paired multiple comparisons with unequal variances at the α = 0.05 level (Keselman and Rogan 1978).

RESULTS

Data for percent undamaged cones as determined by periodic collections of 45-cm branch samples are presented in Table 1. For the collections made on 12 July, which coincided with peak WSBW larval activity, there were no significant differences detected between treatments in each area. In Price Valley, an average of 69% of the cones were undamaged whereas 2% in Idaho City. The majority of damage to cones was caused by the WSBW and coneworms. In Price Valley, WSBW populations averaged 4.5 larvae per 100 shoots on untreated and 3.8 larvae per 100 shoots on treated trees. In Idaho City, the population densities of WSBW larvae averaged 32.6 larvae per 100 shoots on untreated and 30 larvae per 100 shoots on treated trees.

Data for mature cones that were processed by air drying and shaking in paper bags to recover seed are reported in Table 2. There were no significant (5% level) differences detected in the number of filled seed per cone between treatments within each area. In Price Valley, the number of filled seed per cone averaged 25 for treated and 21 for untreated trees; whereas, in Idaho City, 10 for treated and 4 for untreated. Also in Idaho City, the average number of filled seed per cone for those trees receiving acephate was 3 times greater than the number for the untreated checks. In both areas, the Douglas-fir seed chalcid, Megastigmus spermotrophus Wachtl, was recovered in appproximately 3% of the seed.

Data for cones processed by longitudinal dissection or by Lucky Peak Nursery are reported in Table 3. In Price Valley, there were no significant (5% level) differences detected in the number of filled seed per cone between treatments for cones processed by longitudinal dissection. For cones processed by Lucky Peak Nursery the percent germination of sound seeds averaged 80 percent for untreated and 91 percent for treated trees. There were insufficient number of cones on the sample trees in Idaho City to collect for processing by longitudinal dissection or by Lucky Peak Nursery.

DISCUSSION

All treatments (acephate, bendiocarb and oxydemeton-methyl) were

Table 1.--Percent undamaged Douglas-fir cones and populaton densities of western spruce budworm and coneworm larvae as determined by collections of 45-cm branch samples, Idaho, 1982.

Treatment	June 10	July 12		
	Percent undamaged cones	Percent undamaged cones	Larvae per 100 vegetative shoots	
			Western spruce budworm	Coneworm
	$\bar{X}$ ± SE	$\bar{X}$ ± SE	$\bar{X}$ ± SE	$\bar{X}$ ± SE
Maugets		PRICE VALLEY		
-oxydemeton-methyl --15 cm	83.7 ± 5.1	59.8 ± 15.0a[1/]	4.5 ± 1.6	0.4 ± 0.4
-oxydemeton-methyl --10 cm	74.5 ± 8.5	75.3 ± 10.9a	4.9 ± 1.0	2.2 ± 1.2
Medicaps[R]				
-acephate--10 cm	86.6 ± 6.4	82.8 ± 7.4a	3.5 ± 1.3	0.2 ± 0.2
-bendiocarb--10 cm	82.0 ± 3.9	64.8 ± 6.2a	2.3 ± 0.7	1.3 ± 0.5
Checks	75.5 ± 8.9	64.0 ± 12.3a	4.5 ± 1.2	1.0 ± 0.7
		IDAHO CITY		
Maugets				
-oxydemeton-methyl --15 cm	44.7 ± 9.6	0 a	31.2 ± 7.1	3.0 ± 0.6
-oxydemeton-methyl --10 cm	36.3 ± 8.7	2.6 ± 1.8a	26.3 ± 3.1	1.8 ± 0.8
Medicaps[R]				
-acephate--10 cm	35.5 ± 8.8	3.5 ± 2.6a	31.4 ± 5.3	1.8 ± 0.8
-bendiocarb--10 cm	22.3 ± 8.2	0 a	29.3 ± 3.0	2.2 ± 0.8
Checks	6.0 ± 3.0	1.7 ± 1.4a	32.6 ± 4.2	2.3 ± 0.7

1/ Within each study area, means in columns followed by the same letter are not significantly (α = 0.5) different.

Table 2.--Mature Douglas-fir cones processed by air drying and shaking in paper bags to recover seed, Idaho, 1982.

Treatment	No. trees with cones	Total No. cones collected per treatment	Percent filled seed per cone x-rayed	Filled seed per cone
			$\bar{X}$ ± SE	$\bar{X}$ ± SE
		PRICE VALLEY		
Maugets				
-oxydemeton-methyl --15 cm	10	232	77.4 ± 2.8	23.9 ± 4.1a[1/]
-oxydemeton-methyl --10 cm	8	200	75.1 ± 5.8	24.1 ± 3.1a
Medicaps[R]				
-acephate--10 cm	9	225	66.2 ± 9.1	22.7 ± 3.0a
-bendiocarb--10 cm	9	225	85.1 ± 3.2	29.4 ± 3.0a
Checks	10	249	71.8 ± 6.3	21.2 ± 1.9a
		IDAHO CITY		
Maugets				
-oxydemeton-methyl --15 cm	2	25	55.2 ± 7.2	9.1 ± 1.2a
-oxydemeton-methyl --10 cm	4	88	65.0 ±14.6	5.1 ± 1.0a
Medicaps[R]				
-acephate--10 cm	3	69	69.7 ± 5.1	13.0 ± 3.7a
-bendiocarb-10 cm	2	45	57.0 ± 3.0	3.3 ± 1.0a
Checks	2	47	70.0 ± 9.0	4.4 ± 2.7a

1/ Within each study area, means followed by the same letter are not significantly (5% level) different.

Table 3.--Mature Douglas-fir cones processed by slicing longitudinally in half along the cone axis or by Lucky Peak Nursery, Idaho, 1982.

Treatment	No. cones sliced per treatment	Filled seed per cone surface	No. cones processed at nursery per treatment	Filled seed per cone
		$\bar{X}$ ± SE		$\bar{X}$ ± SE
		PRICE VALLEY		
Maugets				
-oxydemeton-methyl --15 cm	200	5.4 ± 0.8a[1/]	3,400	7.9 ± 0.1
-oxydemeton-methyl --10 cm	175	5.5 ± 0.9a	2,600	9.9 ± 0.2
Medicaps[R]				
-acephate--10 cm	212	6.0 ± 0.9a	1,600	8.0 ± 0.1
-bendiocarb--10 cm	225	6.7 ± 1.0a	3,200	9.1 ± 0.2
Checks	50	6.4 ± 2.1a	3,400	9.7 ± 0.1

1/ Means in columns followed by the same letter are not significantly (α = 0.05) different.

ineffective in significantly increasing the number of filled seed per cone in both study locations. In Idaho City, the posttreatment populations of WSBW and coneworm larvae on Douglas-fir were sufficiently high to cause 100% defoliation of new shoots and to prevent the collection of the desired number of cones from the sample trees. This subsequently lowered the sensitivity of the test and our ability to detect significant differences between 4.4 filled seed per cone (untreated) and 13.0 filled seed per cone (Medicaps^{R} containing acephate).

In Price Valley, the populations of WSBW and coneworm larvae on Douglas-fir were too low to detect their affect on the yield of filled seed per cone. Nevertheless, fewer filled seed per cone were recovered by processing at the nursery than by other methods. Apparently, filled seeds were trapped within the cones by growth distortions and excess resin caused by feeding damage and were not recovered during processing.

RECOMMENDATION

These data suggest that Medicaps^{R} containing acephate should be re-evaluated at high WSBW population densities, but with an earlier timing of application and with a greater number of sample trees. We expect that an earlier application timing of Medicaps^{R} would provide maximum levels acephate in midcrown foliage at the time of peak WSBW larval emergence from hibernacula.

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